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Coronavirus Pandemic

The biology of SARS-CoV-2 and epidemiological analysis of COVID-19 pandemic in Nigeria

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Abstract

The pandemic triggered by SARS-CoV-2 continuous to pose a global health threat, with cases of new infections and deaths still occurring despite increasing vaccination efforts. As in other regions of the world, the pandemic has led to unprecedented stretch of health and economic systems in countries in Africa. Nigeria, the most populous African country, has not been spared as the number of new infections continues to teeter amid a high level of vaccination hesitancy. Here, we provided a brief look at the background and biology of the virus. We also highlighted the epidemiology of the virus in Nigeria, as well as the challenges and opportunities it presents. Our review will add to the knowledge of SARS-CoV-2 and the situation of the pandemic in Nigeria, and provide a better response to the pandemic and future pandemics.

Key words: Pandemic; COVID-19; Coronavirus; epidemiology; pathogenesis; Nigeria.

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Introduction

In late 2019, cases of pneumonia with no known origin began to emerge in Wuhan [1,2], a densely populated city in China. An epidemiological investigation initiated by Chinese health authorities at the national and provincial levels revealed a novel, reportable disease outbreak. This disease was confirmed by the World Health Organization (WHO) as a viral disease and announced by its Director-General as coronavirus disease (COVID-19), with the causative agent termed "Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-Cov-2)" [3]. Coronavirus disease (COVID-19) can therefore be defined as a viral infection or disease caused by a new strain of coronavirus that has not previously been identified or associated with humans. Coronaviruses belong to the family Coronaviridae. Viruses in this family are enveloped, non-segmented; with a positive-sense single-stranded RNA genome. Their zoonotic origin was first explained in 1931 and isolated in humans in the 1960s [4]. Pneumonia, cough, fever, difficulty in breathing, sore throat, etc. are some of the symptoms associated with the disease [5]. The susceptibility patterns of SARS-CoV-2 in terms of factors such as gender, age, and other health conditions are similar to those of "Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS)" [6]. A notable feature of COVID-19 is its potential for rapid spread. The magnitude of spread at the onset of the outbreak was noted and therefore, it was declared a global public health emergency of concern on the March 11, 2020 [7].

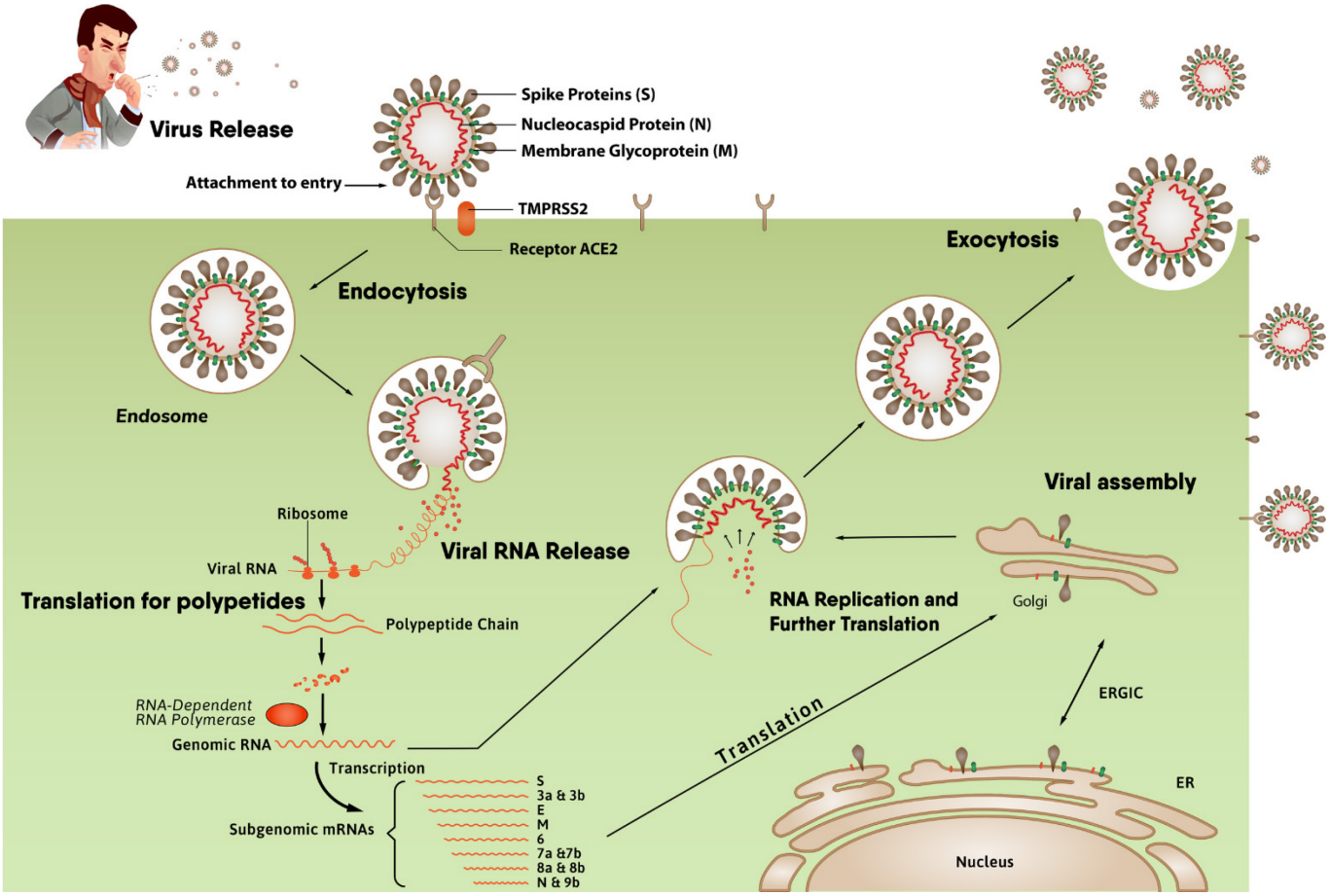
In Nigeria, the first case (index) was a 44-year- old man of Italian origin, who entered the country on a Turkish airline from Milan, Italy. He arrived at Murtala Muhammed International Airport in Lagos, at 10 pm on February 24, 2020. On February 25, 2020, he went to his place of work in Ogun State while at the staff clinic on February 26, 2020, he showed some clinical signs and symptoms of Covid-19 and was suspected to be COVID -19. On February 28, 2020, the suspected case was confirmed as positive by the Minister of Health at a press conference. The confirmed index case was treated at the Infectious Diseases Hospital (IDH) in Yaba, Lagos [8]. The arrival and subsequent confirmation of the first case marked the beginning of the pandemic in Nigeria and the beginning of a very chaotic time for Nigeria.

Virology and pathogenesis of Coronavirus (COVID-19)

Information from homology analysis has revealed structural similarities between severe acute respiratory syndrome coronavirus 1 (SARS-CoV-1) and Middle East respiratory syndrome coronavirus (MERS-CoV) and as such, COVID-19 could also have a similar pathogenetic route as these viruses. The already known clues concerning the pathogenesis of SARS-CoV and MERS-CoV can give us vital information regarding the pathogenesis of SARS-CoV-2 from infection to possible disease outcome regardless of severity [9].

In general, coronaviruses are associated with respiratory and gastrointestinal tract infections as important pathogens in both humans and animals. They are spherical, enveloped, and 100-160 nm in diameter, with each particle having a single-stranded positive sense ribonucleic acid (RNA) genome that is approximately 27-32kb in size. The virus has a 5' cap structure, which has a protective function and supports ribosomal binding, and a 3' poly-A tail, which has an export and binding function during transcription. Starting from the released viral RNA, the synthesis of the polyprotein 1a/1ab is achieved in the host [10]. Transcription occurs through the "replication-transcription complex" organized in double-membrane vesicles and synthesis of subgenomic RNA sequences. Remarkably, the termination of transcription occurs at transcriptional regulatory sequences located between the open reading frames that serve as templates for the production of subgenomic mRNAs [11]. In a normal SARS-CoV genome, at least six open reading frames (ORF) are found. Of these frames, a frameshift lies between ORF1a and ORF1b, which controls the production of pp1a and pp1ab polypeptides processed by virally encoded "chymotrypsin-like proteases or major proteases" and 1 or 2 papain-like proteases to produce sixteen non-structural proteins [11]). In addition to ORF1a and ORF1b, other ORFs are known to encode structural proteins such as spikes (S), the envelope (E), the membrane (M), the nucleocapsid (N), and other helper proteins [12,13]. The M protein binds the nucleocapsid and is involved in viral assembly and budding, while the E protein is involved in viral morphogenesis and pathogenesis. The S protein forms

Figure 1. Infographic Illustration of the Pathogenesis of SARS-CoV-2.



spikes that recognize the cellular receptor, allowing the virus to enter target cells [10].

SARS-CoV-2 viruses look like crowns when viewed with an electron microscope, which is due to the glycoprotein spikes on their envelope [14]. The S protein plays a critical role in supporting the virus' entry into host cells by binding to its biological receptor angiotensin-converting enzyme 2 (ACE2). SARS-CoV-2 spikes have a higher binding affinity for ACE2 than SARS-Cov-1, promoting the transmission properties of SARS-CoV-2 [9]. Several researchers believe that CD209 and CD209L are the elective receptors that allow the virus to attach to host cells. However, the mechanism by which this is achieved is not clear [15-18]. In general, it is believed that COVID -19 is transmitted from person to person, mainly through droplets in the respiratory air expelled by an infected person when speaking, coughing, or sneezing. These infectious droplets can enter the mouth or nose of people who are in close proximity to the infected person, or possibly be inhaled into the lungs. After the virus attaches and enters the cells, the viral RNA genome is released into the cytoplasm, where it is expressed into two polyproteins and structural proteins, whereupon the viral genome begins to replicate (Figure 1). The newly formed envelope glycoproteins are incorporated into the sheets of the endoplasmic reticulum (ER) or Golgi apparatus, and then the nucleocapsid protein. The viral fragments sprout into the ER -Golgi intermediate region. The vesicles containing the viral fragments combine with the plasma membrane and release the virus by exocytosis [18-19]. Li *et al.* [20] further explained that the virus can enter the peripheral blood from the lungs and cause viremia. Through the mucous membranes, the virus attacks its host, especially the nasal and laryngeal mucosa, and then enters the lungs through the respiratory tract. Alveolar epithelial cells in the lungs are the cells most affected by the SARS-CoV-2 virus [20]. In addition, organs that express the ACE2 receptor, such as the lungs, heart, kidneys, and gastrointestinal tract, are targeted by the virus [21-22].

The virus triggers a secondary attack that worsens the patient's condition about 7 to 14 days after the onset of the disease. There may be a decrease in beta-lymphocytes (β-lymphocytes), which affects the patient's antibody production. Inflammatory factors associated with the disease, especially IL -6, increase significantly and may also influence the worsening of the disease between two and ten days after onset [14].

Immune response

Under normal circumstances, the entry or presence of a viral particle in a host triggers an immune response that involves a complex interplay between the virus, host immune cells, and target cells. Once the viral fragments enter the host cells, an immune response occurs as the antigen rapidly introduced to the antigen-presenting cells via the major histocompatibility complex (MHC)/human leukocyte antigen system [16,19,23]. Recent studies show a marked decrease in CD4+ and CD8+ T cells in the peripheral blood of COVID -19 patients [9]. In addition, many studies suggest an uncontrolled central defence response against the virus due to cytokine storm and increased levels of chemokines [17,20,24]. Available data suggest that viral infection can trigger an excessive immune response in the host. In some cases, this response occurs and is referred to as a "cytokine storm." The result of this event is extensive tissue damage. Interleukin 6 (IL -6), produced by activated leukocytes, is involved in this storm. IL-6 acts on a large number of cells and tissues [25]. Also, it is able to promote β lymphocytes differentiation, promotes the growth of certain categories of cells while inhibiting the growth of others. It is also able to stimulate the production of acute-phase proteins and plays an important role in thermoregulation in bone maintenance as well as the functionality of the central nervous system [21]. IL -6 mainly plays a pro-inflammatory role. However, it may also have anti-inflammatory effects. It has been found to increase in infections, inflammatory diseases, autoimmune diseases, some cancers, and cardiovascular diseases [22]. It has been found to play a role in the development of cytokine release syndrome, an acute systemic inflammatory syndrome characterized by fever and multiple organ failure [26]. The "cytokine storm" triggered by the immune system leads to obstruction of the respiratory system, resulting in acute respiratory distress syndrome (ARDS) and ultimately death [15,23].

Clinical Manifestation of COVID-19

The clinical spectrum of COVID -19 ranges from "asymptomatic" at one end of the spectrum to "clinical" at the other end of the spectrum, with varying degrees of severity that can range from severe respiratory failure requiring mechanical ventilation and support in an intensive care unit to multi-organ and systemic manifestations such as sepsis, septic shock, and multiple organ dysfunction syndromes [27]. Common symptoms include fever, cough, dyspnea, headache, sore throat and rhinorrhea, loss of smell and/or taste. To

date, pneumonia appears to be the most common severe clinical manifestation of the infection [28]. In addition, respiratory and gastrointestinal symptoms, i.e., nausea and diarrhea, have also been reported. The majority of people who become ill due to COVID -19 have mild symptoms and recover without special medical measures.

Epidemiology of COVID-19 in Nigeria

As of June 19, 2021, a total of 167,153 confirmed cases of COVID -19 have been reported in Nigeria, while a total of 163,540 people have been discharged after testing negative for the virus following infection. The disease has resulted in 2,117 deaths, representing a mortality rate of 1.26% of confirmed cases. To date, cases of COVID -19 have been reported in all 36 Nigerian states, with Lagos State being the epicenter of the disease in Nigeria (Table 1).

COVID-19 is disproportionately common in certain locations, with very few cases reported in some states despite similar exposure risk. In Nigeria, COVID -19 has been detected in all age groups (children, adults, and elderly). Mortality rates were observed to increase with age. Although most infections occurred in people aged 25-44 years, the majority of deaths were in people aged 45-74 years (Figure 2). The mortality rate is higher in people older than 75 years, with a mortality rate > of 3% in both men and women. However, the infection rate is higher in men than in women. At least 2,225,765 doses of the COVID -19 vaccine have been administered as of June 21, 2021, as the country hopes to consolidate past successes in combating the pandemic. Although Nigeria has taken measures to manage a possible third wave, it was observed that the second wave was more severe than the first wave. Between February and October 2020 (first wave),

Table 1. Epidemiology of COVID-19 by states in Nigeria as of 19/06/2021.

States Affected	Number of Cases (Lab Confirmed)	Number of Cases (on admission)	Number of Discharged Persons	Number of Deaths
Lagos	59,315	344	58,515	456
FCT	19,878	507	19,205	166
Kaduna	9,107	11	9,031	65
Plateau	9,063	1	9,005	57
Rivers	7,295	29	7,165	101
Oyo	6,858	0	6,734	124
Edo	4,910	2	4,723	185
Ogun	4,683	0	4,633	50
Kano	4,000	22	3,868	110
Ondo	3,432	139	3,229	64
Kwara	3,137	14	3,068	55
Delta	2,648	20	2,556	72
Osun	2,578	6	2,520	52
Enugu	2,464	100	2,335	29
Nasarawa	2,384	1	2,344	39
Katsina	2,110	21	2,055	34
Gombe	2,075	6	2,025	44
Ebonyi	2,039	5	2,002	32
Akwa Ibom	1,927	8	1,901	18
Anambra	1,909	64	1,826	19
Abia	1,693	2	1,669	22
Imo	1,661	4	1,620	37
Bauchi	1,549	0	1,532	17
Benue	1,366	15	1,327	24
Borno	1,337	99	1,200	38
Adamawa	1,131	1	1,098	32
Taraba	1,001	0	977	24
Niger	935	5	913	17
Bayelsa	906	1	879	26
Ekiti	877	3	863	11
Sokoto	775	0	747	28
Jigawa	533	5	512	16
Yobe	478	18	451	9
Kebbi	450	42	392	16
Cross River	402	0	384	18
Zamfara	244	3	233	8
Kogi	5	0	3	2

nearly 8,000 cases were registered each month, while the second wave registered an average of 18,000 cases (November 2020 and February 2021).

Challenges in controlling COVID-19 in Nigeria

The rapid spread and novelty of the virus, as well as vaccination fatigue, pose the greatest challenges in combating the pandemic. Although testing capacity has been scaled up in Nigeria, testing and identifying positive cases remains a challenge. As of 10:56 a.m. Saturday, June 19, 2021, only 2,231,409 samples have been tested for a population of more than 200 million people.

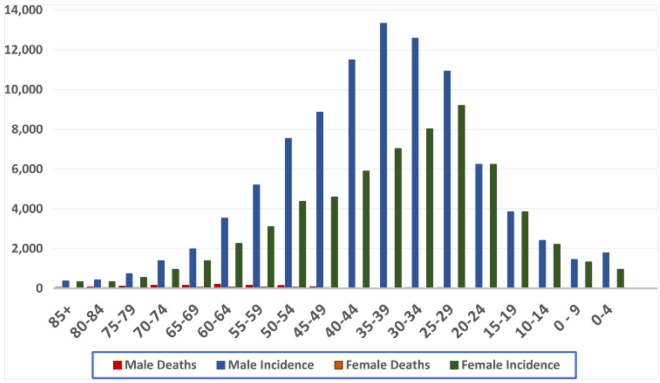
Another challenge in combating the pandemic in Nigeria is the lack of adherence to non-pharmaceutical preventive measures. Lack of personal protective equipment for all healthcare workers at all levels also remains a challenge in Nigeria, as does inadequate healthcare funding. Of even greater concern is the constant politicization of the pandemic in Nigeria, which means that many Nigerians continue to doubt the existence of the disease in the country and therefore do not take seriously the guidelines issued by the government on COVID -19 prevention.

Prospects of the pandemic in Nigeria and other African countries

Before the first case of COVID -19 appeared on the African continent, the prevailing global view was that Africa would be the hardest hit region in terms of mortality due to the weak state of health systems in many African countries. However, as the pandemic continues to spread, other regions of the world have so far experienced more deaths and infections than Africa.

The pandemic provides a good opportunity for Nigeria and other African countries to rebuild and transform their health systems to better respond to future epidemics. In Nigeria, a good number of health workers have been trained in public health safety measures. So far, the Nigerian Institute of Medical Research has already contributed to expanding the country's testing capacity by launching the country's first set of local ribonucleic acid purification kits. As of May 14th, 2020, the National Agency for Food Drug Administration and Control (NAFDAC) had received one application for a product being presented for treatment of COVID-19 symptoms, which was approved, while many others are being guided in submitting their products (medicines) for evaluation and possible approval. Madagascar's herbal remedy (Covid organics) has also been evaluated and found ineffective for the treatment of COVID-19 by the National Institute of Pharmaceutical Research and Development.

Figure 2. Epidemiology of COVID-19 by age and gender in Nigeria (NCDC Week 10-21).



Conclusions

Although the spread of COVID-19 has been reduced around the world, with morbidity and mortality rates in decline. In some parts of the world, there seems to be a resurgence of the disease in areas where the pandemic was believed to be under control. Due to a lack of adherence to the guidelines issued to control the spread of the disease, it appears that the lockdown in Nigeria had no effect in halting and reversing the disease's spread. However, the national lockdown imposed to combat the spread of the diseases has been lifted and the infection rate has significantly reduced. While NAFDAC continues to evaluate the effectiveness of products currently under review for the control or treatment of COVID-19, the country has since scaled up vaccination efforts, with more people gradually taking the vaccine. There is still cautious optimism that the pandemic is under control in Nigeria. Hence, the health authorities are still advising a strict adherence to physical distancing, the use of proper face masks in public, and the practice of hand and respiratory hygiene.

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